New insights into magma storage under the Katmai volcanic cluster

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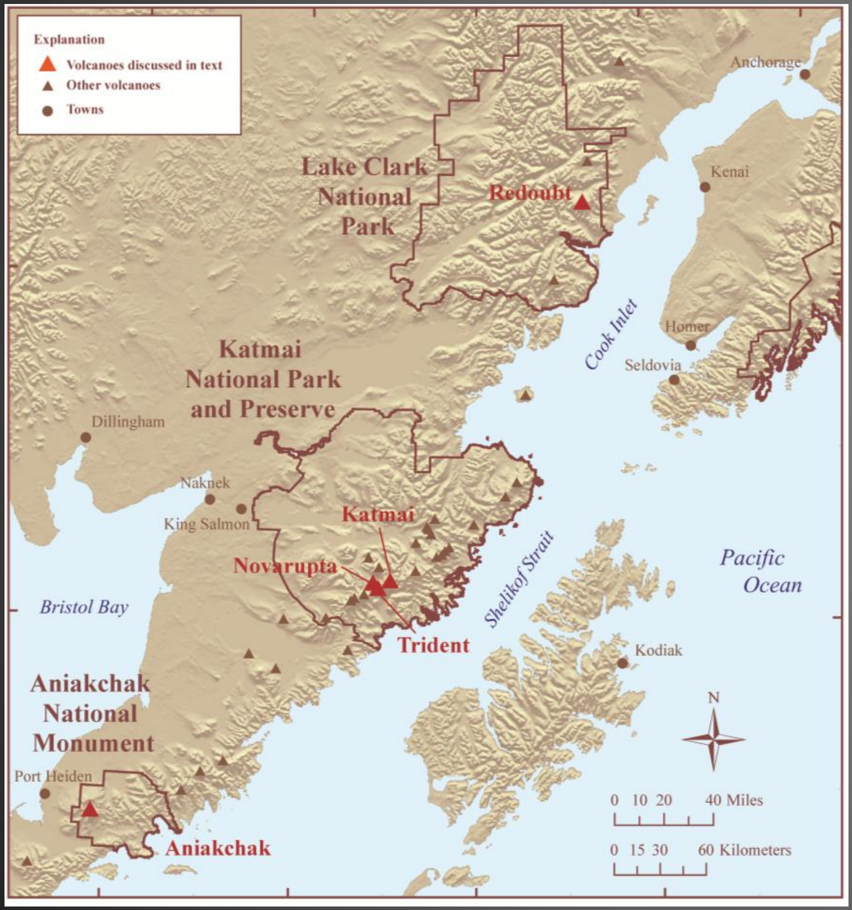
Outline



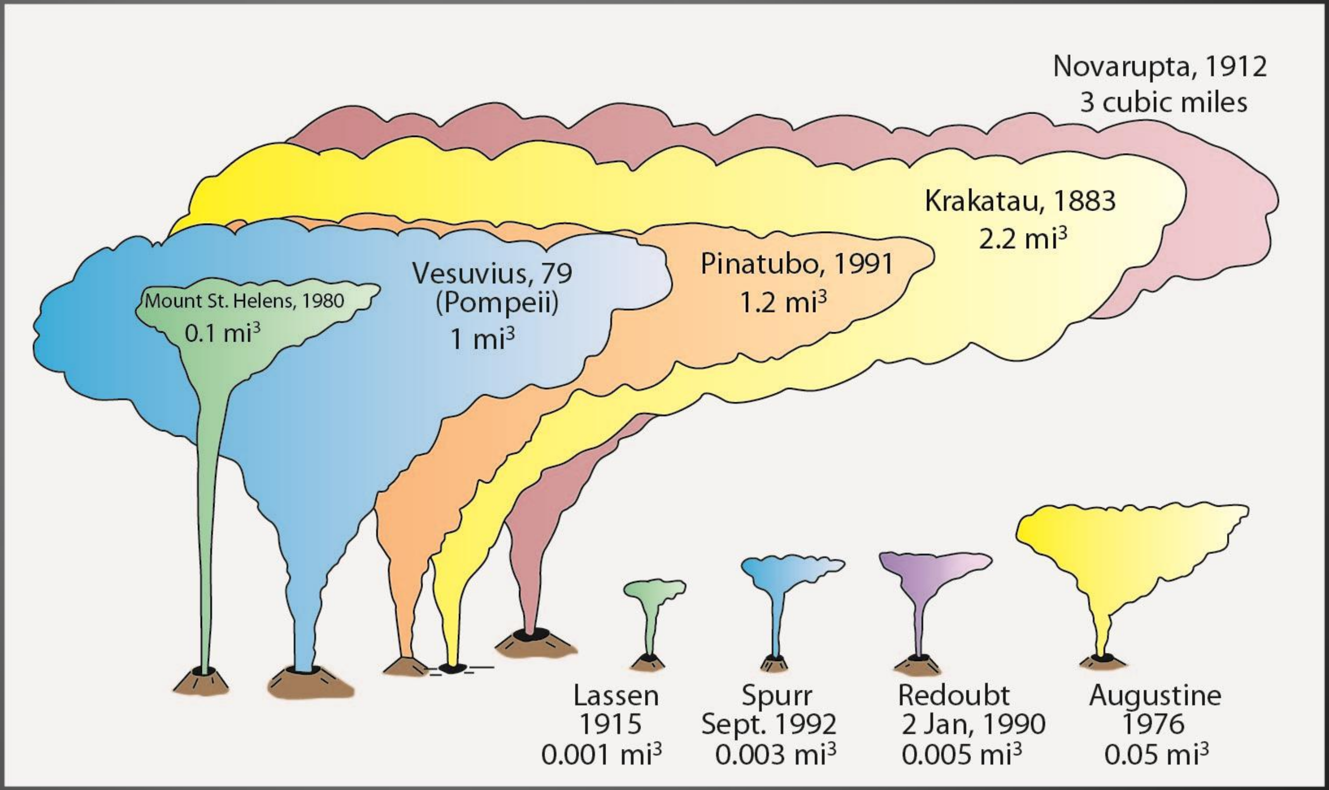
- Outstanding features of Katmai National Park
- Volcano monitoring and hazards
- Remaining questions about 1912 eruption
- Recent geology and geophysical results

Outstanding features of 1912 eruption

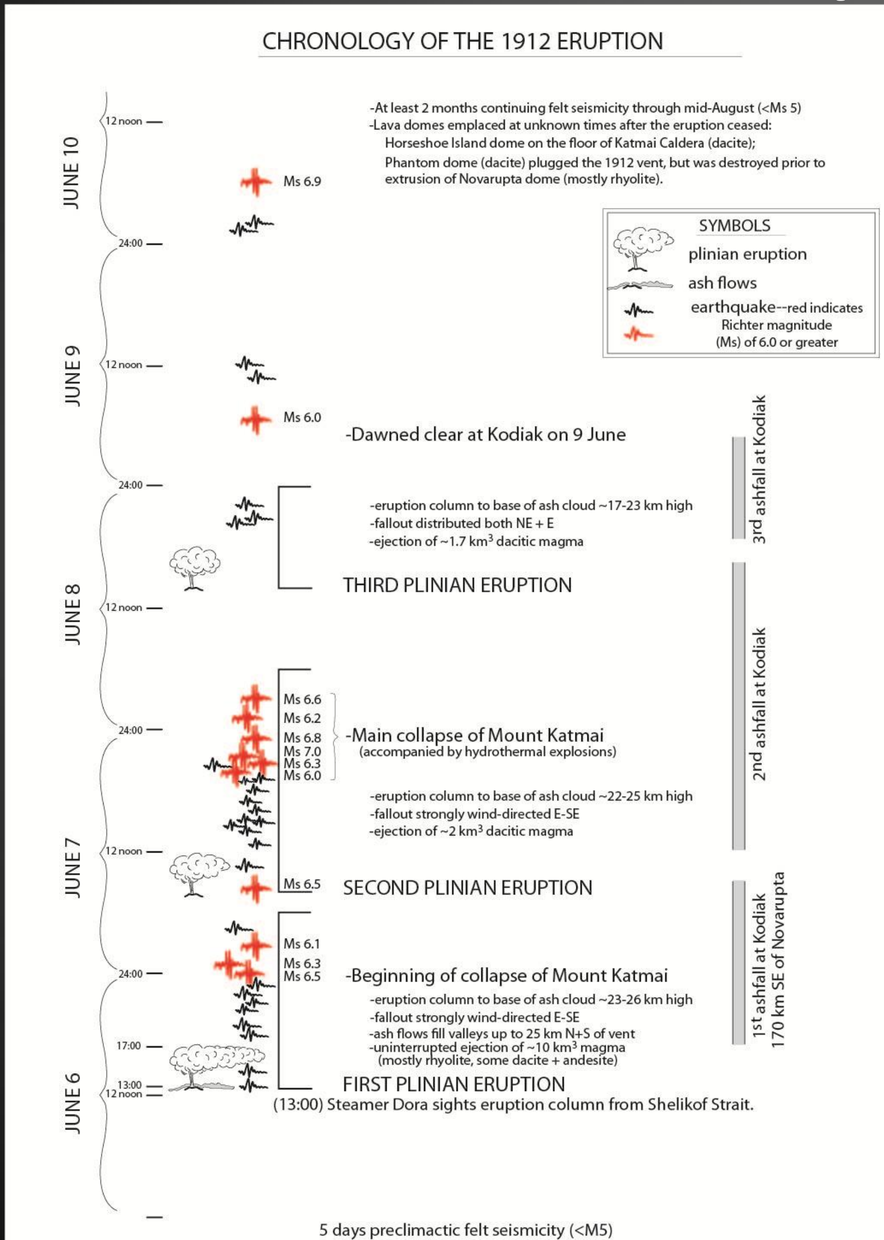
- Erupted 13 km^3 of magma as ~30 km^3 of pumice and ash
- Caldera collapse occurred 10 km from the vent
- Only historical ash-flow tuff, or *ignimbrite* (VTTS)

Outstanding features of 1912 eruption

- Erupted more ash than all other historical Alaskan eruptions combined
- Lowered Northern Hemisphere temperatures by 2^o F for 1 yr
- Erupted nearly crystal-free high-silica rhyolite



The 1912 eruption sequence



- •Episode 1 - began with eruption of rhyolite-only ash fall and minor ash flow, then switched to predominantly ash flow when dacite and andesite magma were introduced.
- •Episodes 2 and 3 were dominated by dacite ash fall and subordinate ash flow deposits.
- •400-m-wide rhyolite dome (Novarupta) probably formed weeks to months later

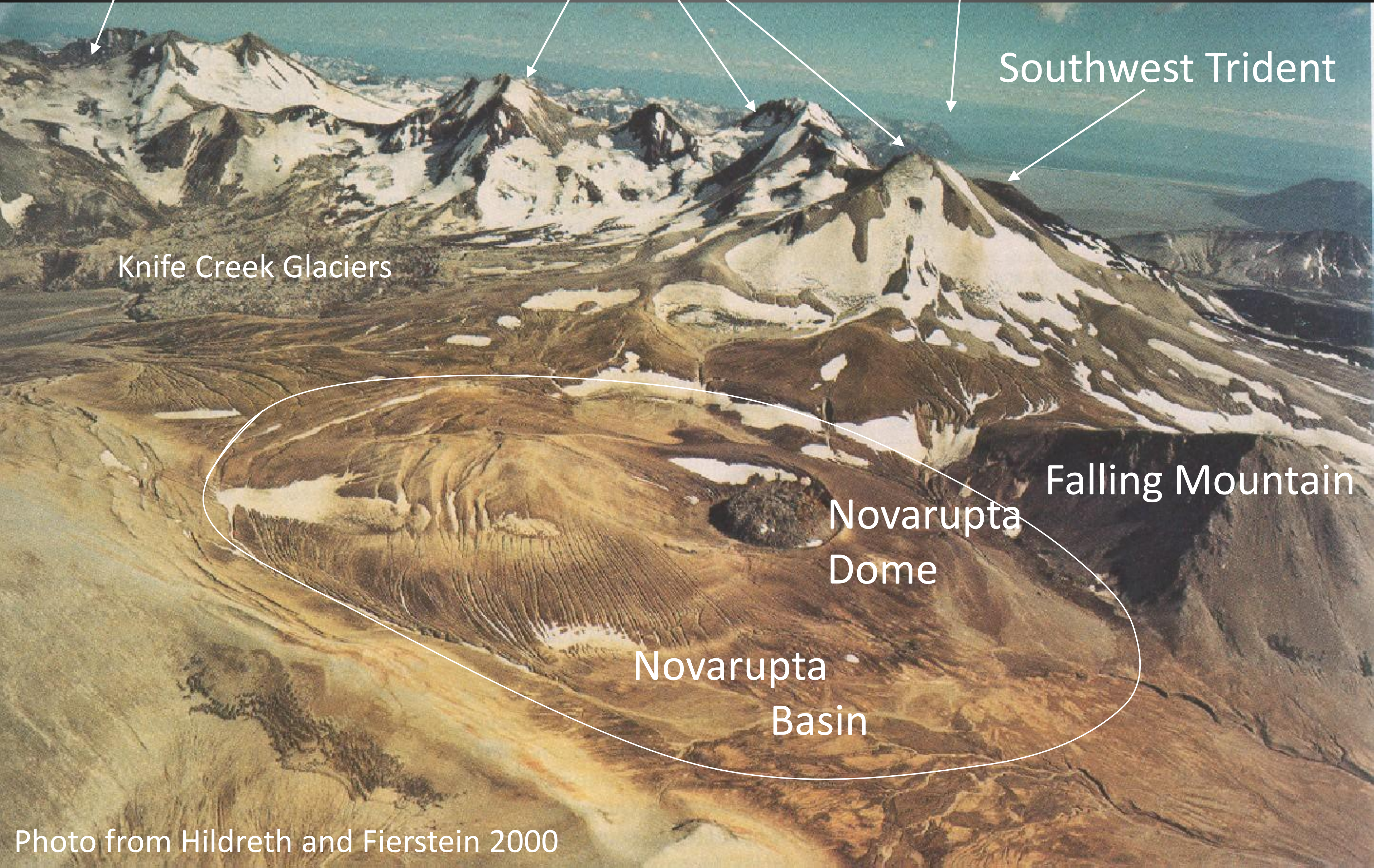


Photo from Hildreth and Fierstein 2000

Katmai volcanic cluster

Southwest Trident eruption, 1953

- ~6 closely spaced stratocones
- 1953-1974 eruption of Southwest Trident produced 0.5 km^3 of andesite
- Very seismically and fumarolically active today

100 years later - Significance to volcanology

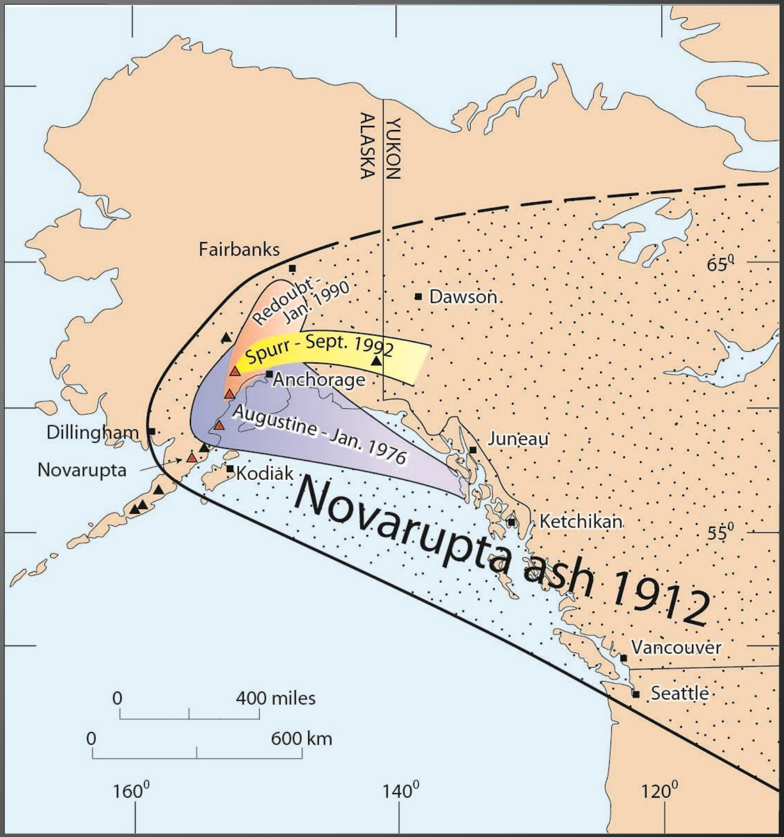
- Ash-flow emplacement
- Proximal studies of Plinian (highly explosive) deposits
- Magmatic evolution (mixing versus fractionation)
- Unusual magma “plumbing” system

Monitoring and hazards

Monitoring requires understanding of what volcanoes are capable of and how they work, and interpretation of geophysical signals

John Paskievitch (USGS AVO) servicing a webcam mounted on solar panels at seismometer site KABU in Katmai National Park and Preserve

Primary hazards are airborne ash and ash fall

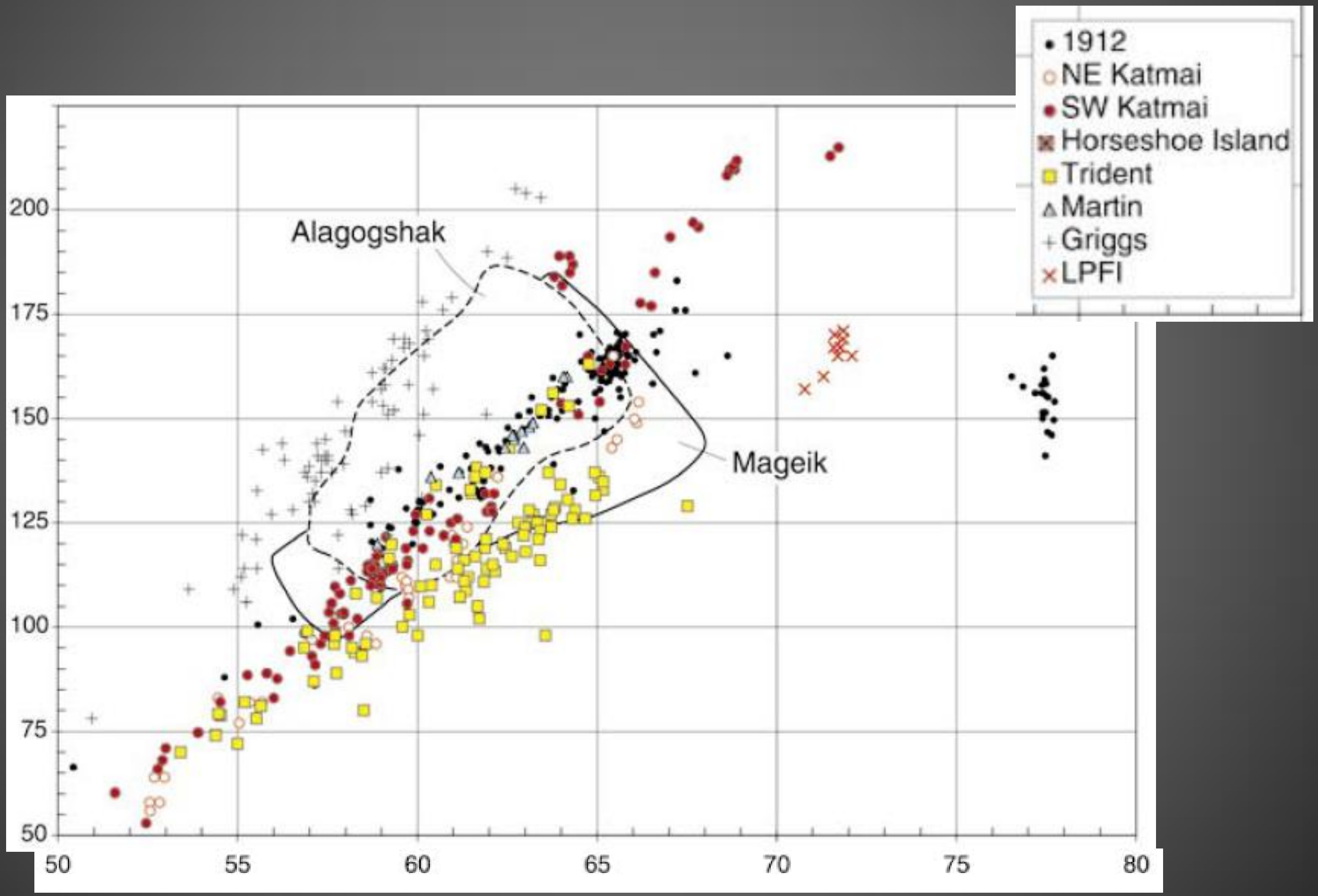


Outstanding magmatic questions

- How was large body of rhyolite magma generated? Will it happen again?
  - Single zoned body (fractional crystallization)
  - Remelting of old rocks
- Where were 1912 magmas stored prior to eruption?
- Is there a connection to 1953-1974 eruption of Trident?

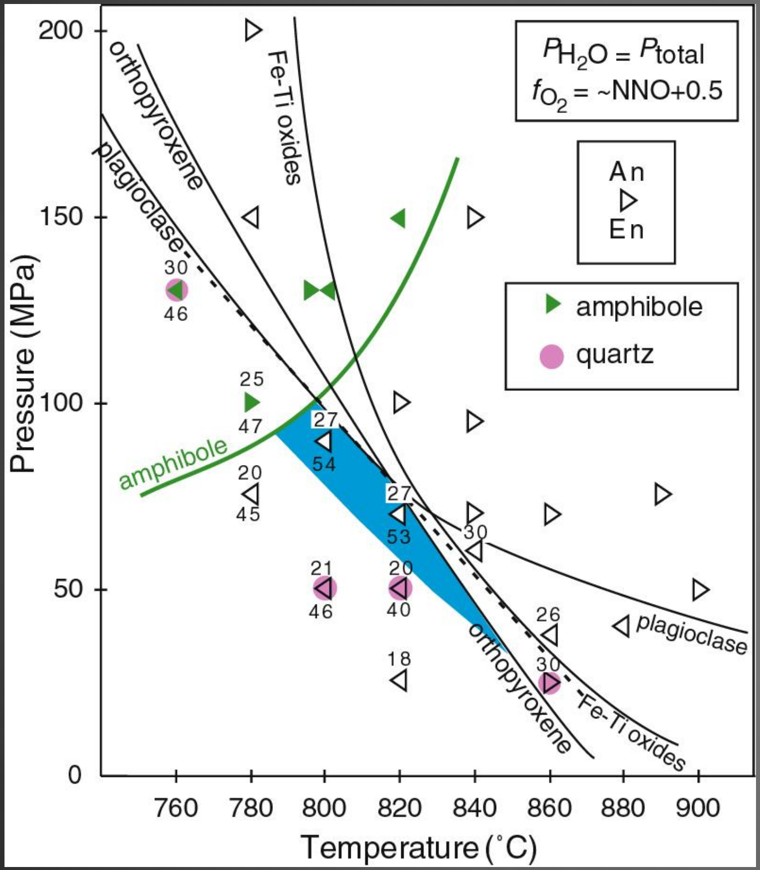
Compositional affinities of erupted magmas (Hildreth and Fierstein, 2012)

Zr (ppm)



SiO_2 (wt%)

Results from experimental petrology

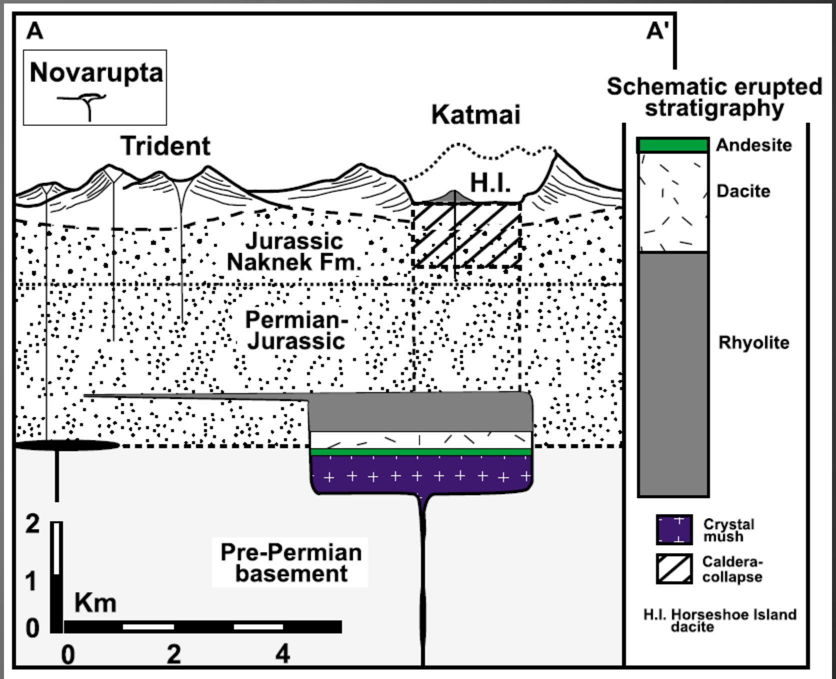


Blue field shows where the minerals present in the 1912 rhyolite are stable

- Rhyolite stored at 40-100 MPa, or ~2-4 km depth (Coombs and Gardner, 2001)
- Andesite and dacite stored at 25-100 MPa, or 1-4 km depth (Hammer et al., 2002)
- Both quite shallow (crust is 25+ km thick here)

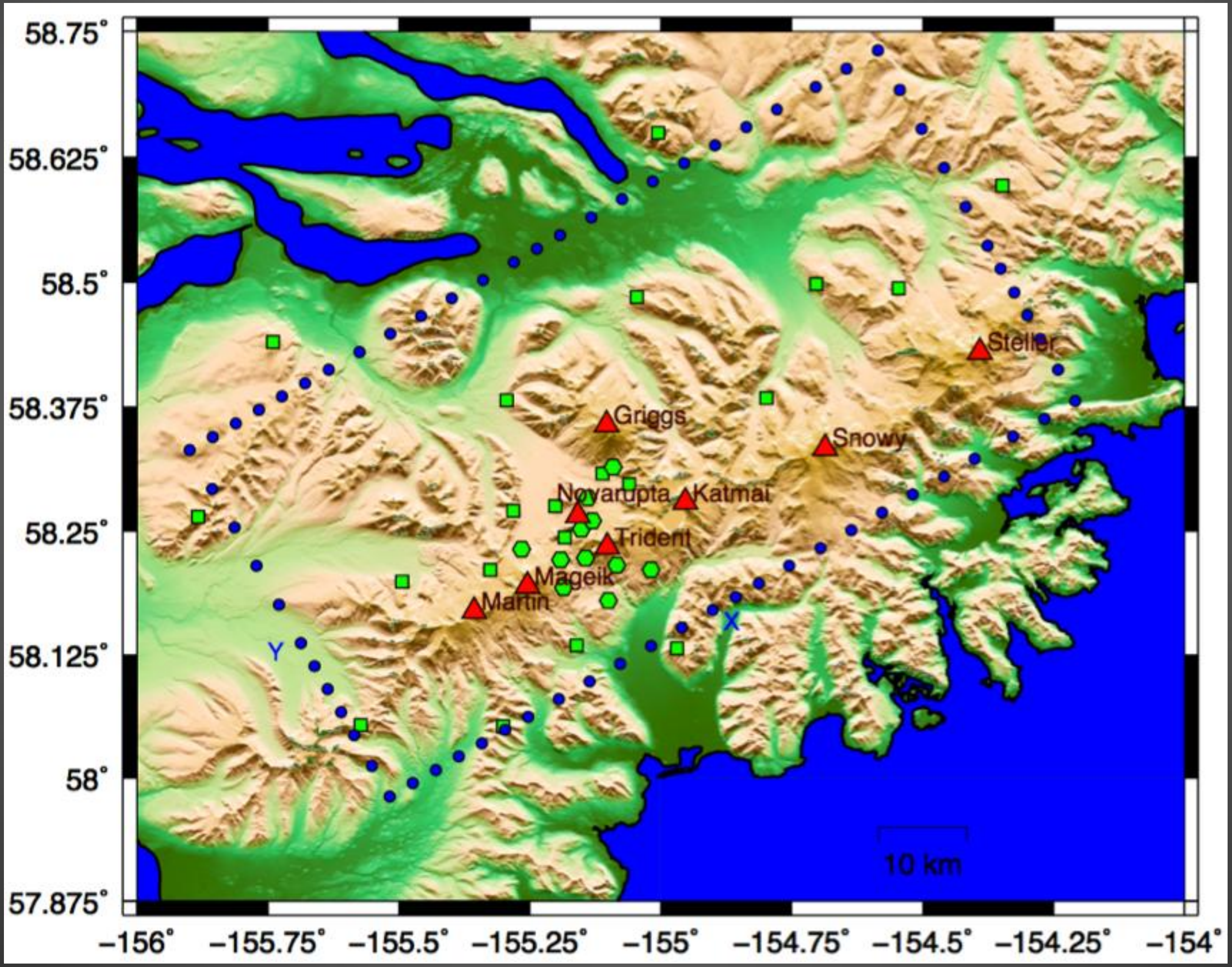
Results from radiogenic isotopes (Turner et al., 2010)

- Andesite - <1000 yrs old ($^{226}Ra/^{230}Th$)
- Dacites – up to 8,000 yrs old ($^{230}Th/^{232}Th$)
- Rhyolite – 50-100,000 yrs old ($^{230}Th/^{232}Th$)
  - Solidified, then thawed by hotter magmas



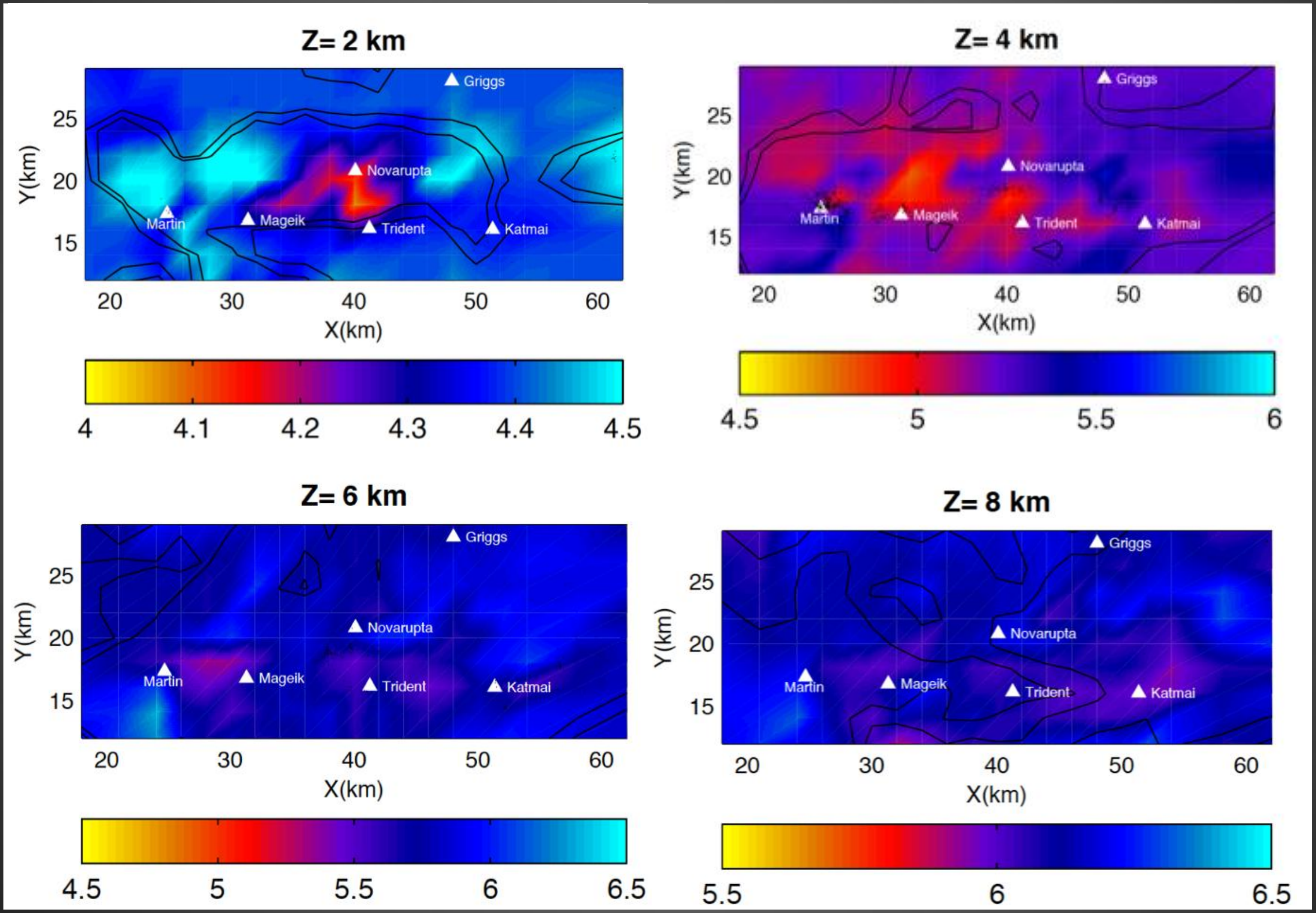
Ages not consistent with closed-system evolution of all 3 magmas

USGS-University of Wisconsin seismic imaging experiment (2008-2010)

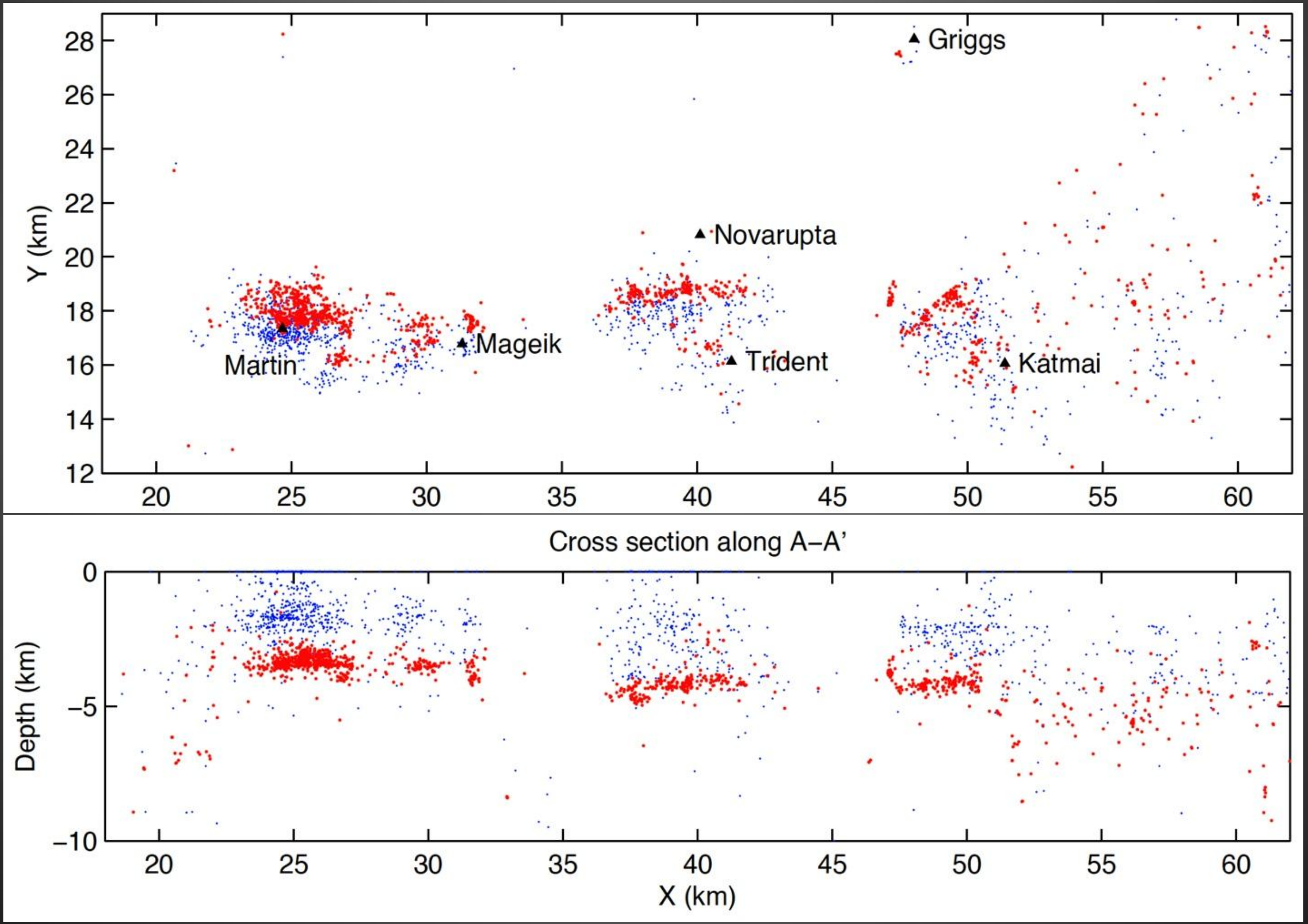


Green squares - AVO permanent stations; green circles - AVO/UW temporary stations.

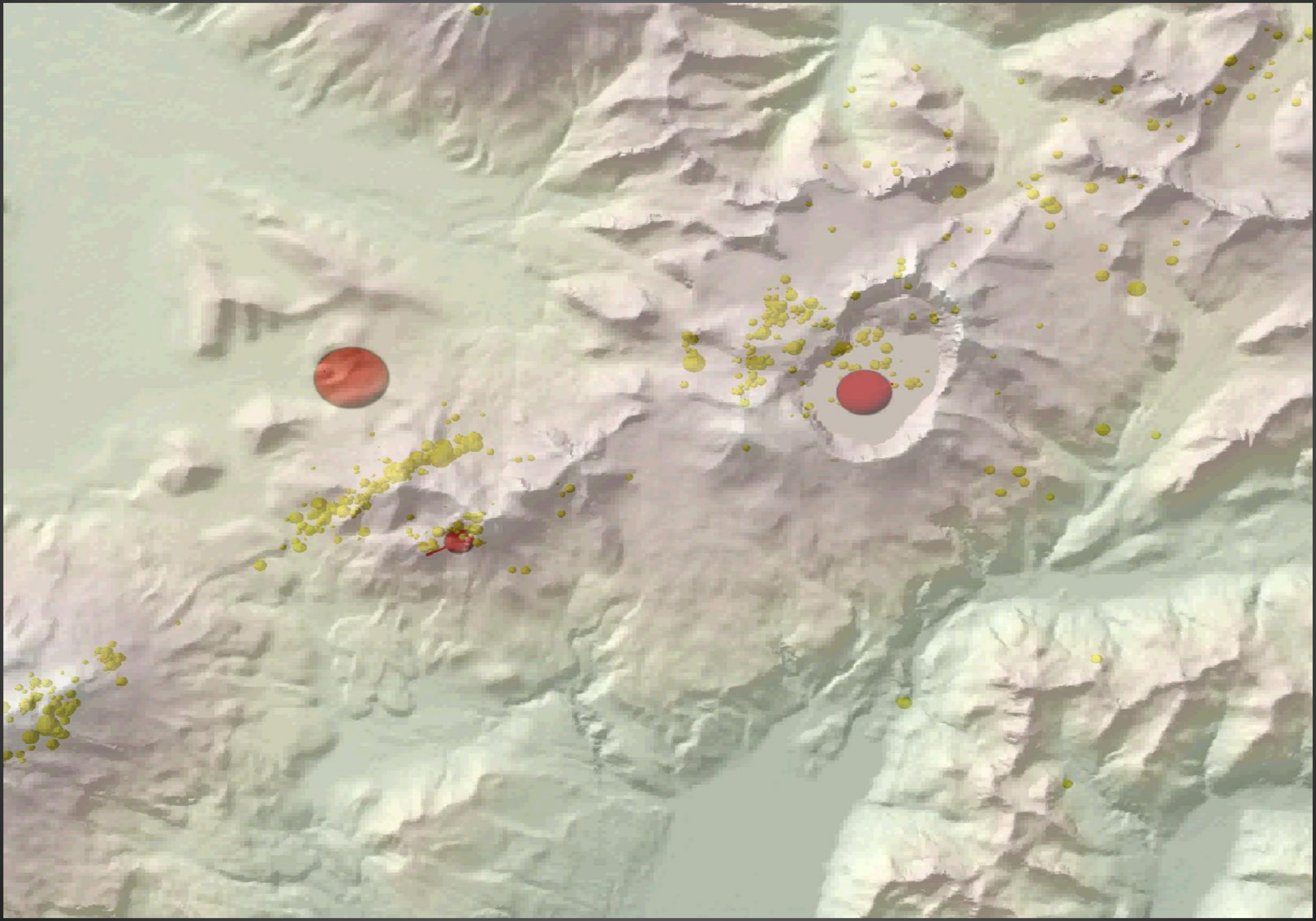
P-wave tomographic slices



Earthquake relocations using double-difference technique



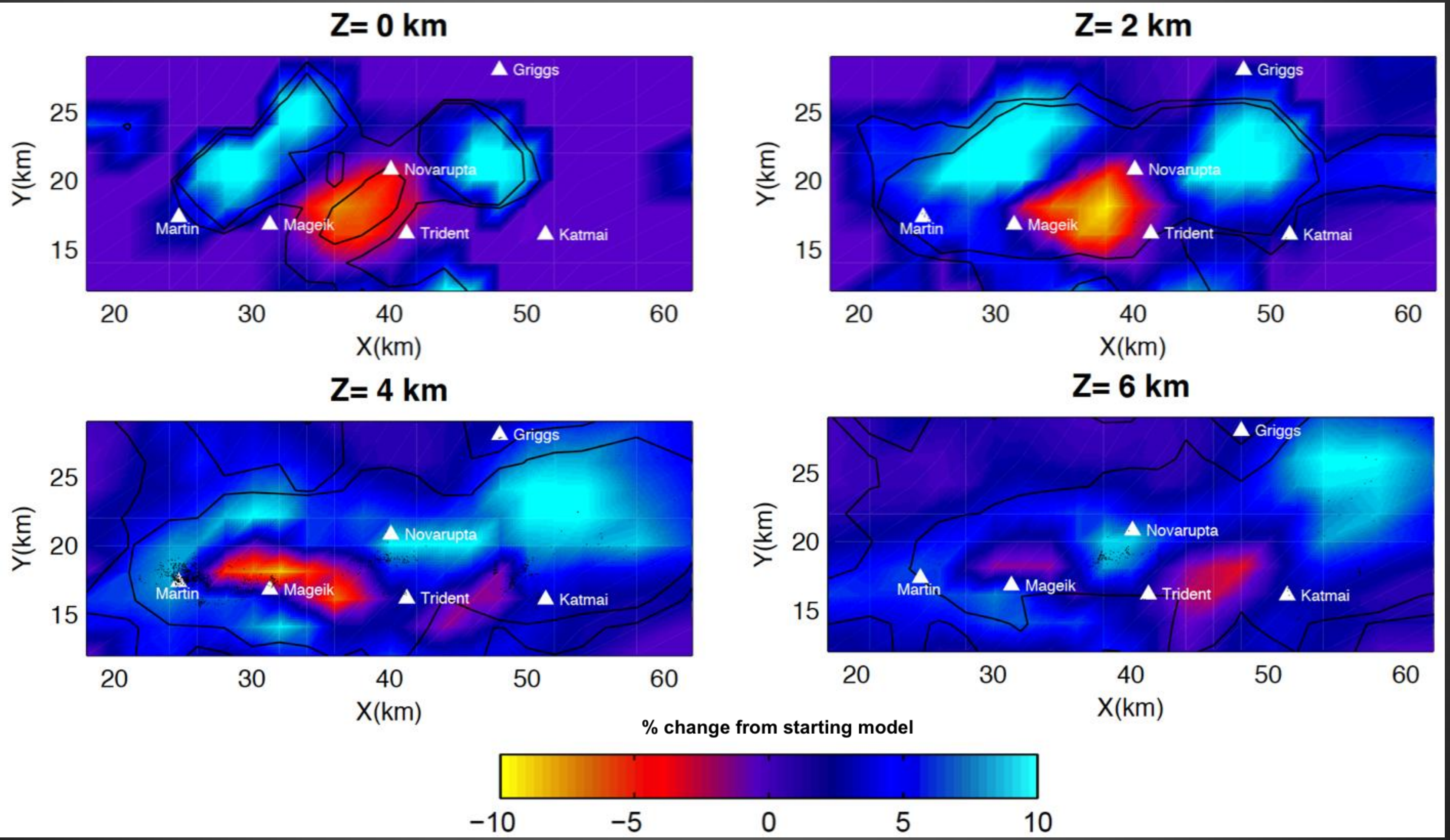
Earthquakes and estimated magma withdrawal volumes



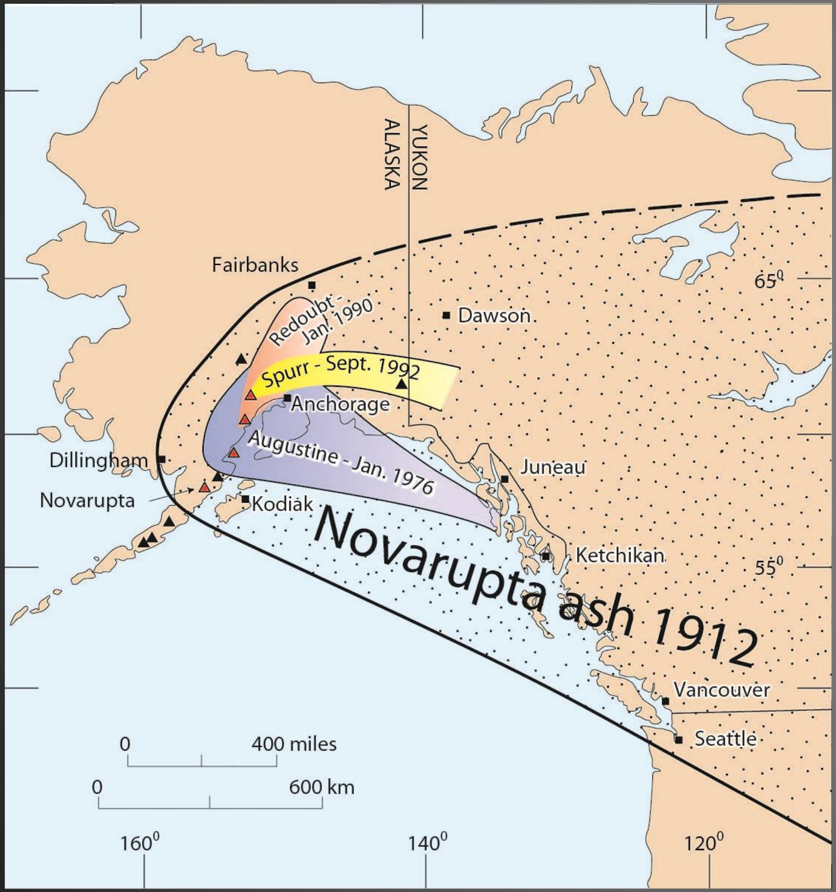
Conclusions

- 1912 magmas likely not the products of closed-system evolution in a single magma chamber (instead thawing of previously solid igneous rock?)
- Little/no residual magma currently in the shallow crust beneath Katmai
- Introduction of new magma will likely be heralded by increase in seismicity, gas output, etc.

S-wave tomographic slices



Hazards



- Airborne ash and ash fall are the two primary hazards
- Locally, pyroclastic and debris flows can be devastating